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ABSTRACT

The use of Mobile and Wireless Information Technologies (MWIT) for the provision of public services by the government is a relatively recent phenomenon. This paper evaluates the results of mobile technology adoption by the IBGE (The Brazilian Institute of Geography and Statistics), via a case study. In 2007 the IBGE applied 82,000 mobile devices (PDAs) for data collection in a broad census operation in Brazil. The challenges for the deployment of MWIT in a large scale required a sheer work on innovative working practices and service goals. The case studied reveals a set of outputs of this process, such as the time and costs reduction in service provision, improvements on information quality, staff qualification and increase in organizational effectiveness.

Keywords

Mobile technology, IT adoption, e-government, IS evaluation.

1 - INTRODUCTION

In the last two decades we have witnessed a rapid spread of Mobile and Wireless Information Technology (MWIT), which include mobile devices such as the mobile phone, PDAs (Personal Digital Assistants), smartphones, RFID (Radio Frequency Identification), wireless networks, as well as mobile information systems (Agar, 2004).

In the academic literature currently available, there are several studies that focus on the use of MWIT and its impact for individual users or for specific societies or groups (e.g. as those presented in Katz, 2008), but there are still few studies that examine the effects of this technology in organizations. For Sørensen et al. (2008) enterprise mobility – the use of mobile devices for enterprise operations - creates new organizational forms to manage the way people work collaboratively. Complementary to an increase in the use of MWIT are the efforts to improve organizational efficiency and effectiveness. Although these issues are very important to organizational practice, its relevance is not reflected in the current IS literature, which has dedicated very little attention to corporate mobility (Sørensen et al., 2008).

We can also highlight the scarcity of academic studies showing criteria, typologies, frameworks or models to evaluate the actual results of investments made by organizations in the adoption of MWIT. This is particularly true when related to services, which tend to adopt these technologies in greater proportion (Mathiassen & Sørensen, 2008). If we consider a more precise focus within the services sector, there is an array of possibilities for mobile application in public and governmental services, which can involve a wide geographical area and a potential significant number of users. Therefore, it is relevant to generate references that can help to evaluate the results of MWIT use in this context.

This paper presents results of a research project that aims to assess the results of MWIT adoption for the provision of services by public organizations. The research is based on a case study about the use of MWIT by the IBGE (The Brazilian Institute of Geography and Statistics). The IBGE is a Brazilian federal institution, subordinated to the Ministry of Planning, and it is the

main provider of statistical information about the country, meeting the needs of the various segments of civil society and the governmental spheres. In 2007, the IBGE innovated by replacing paper questionnaires by electronic questionnaires accessed by census workers in field work via PDAs, in a complex census operation. This case of MWIT application received national and international attention, since the IBGE deployed 82,000 mobile devices in this operation, in a continental country with many different local realities. Therefore, it represents a unique situation, which is worthy to be documented and evaluated, with the potential to serve as a reference for other cases of MWIT applications in public services.

The article is structured as follows: section 2 presents the research theoretical base. Section 3 explains its methodology and analyzes data collected in the case study. Section 4 presents a summary of results, a discussion and some final comments.

2 – THEORETICAL BACKGROUND

Some authors such as Welin-Berger (2004) point out internal and external gains with the application of MWIT in organizational processes. Internally, there are efficiency gains, as the receipt of requests made remotely; the reduction of back office tasks (e.g. done during fieldwork); direct access to information about inventory and delivery time by the staff in the field, and also direct access, anywhere, to product information, manuals, technical documentation, etc.. From an external perspective (customers) there are gains such as easy access to product requests information, services offered through a mobile channel, as well as context aware information. All these possibilities can generate organizational quantitative gains such as cost reduction in administrative tasks and logistics, efficiency gains in fieldwork and increased revenue. They can also generate earnings such as a better planning and location of the mobile workforce, error reduction, a better inventory control, as well as faster and more accurate information and communication (Welin-Berger, 2004).

However, typologies, models or frameworks for the assessment of MWIT adoption results in organizations are still scarce. Scheepers & Mckay (2004) present one of the few studies that classified the results of MWIT adoption according to three types of benefits: *Type 1* – related to the motivation and satisfaction of people in the adoption of technology, combined with the increase of data quality and data exchange; *Type 2* – related to efficiency and productivity gains and *Type 3* - the effectiveness of the company, involving customer satisfaction and retention, and increases in revenue. This typology follows the same rationale of generic models for the assessment of IT adoption results, such as those proposed by DeLone & McLean (1992), Mirani & Lederer (1998), Mahmood & Soon (1991) and Smithson & Hirschheim (1998). These models are widely referenced and replicated in the IS literature. Some of the variables presented by these models, such as flexibility gains, better decisions, improvement in the pattern of communication, coordination of activities, cost reduction, or increase in staff productivity, can also contribute to the evaluation of the results of IT adoption in the public sector.

However, evaluating IT investments in the public area requires us to consider the idiosyncrasies of public organizations. Private organizations are usually keen to invest in IT in order to gain competitive advantages, and in the search for economic and financial benefits. In public organizations there are political objectives and the development of systems is aimed at meeting the needs of the different stakeholders involved (Heeks, 2002). Rather than the increase in efficiency and effectiveness in public processes, Avgerou et al. (2005) highlight that IT is a powerful tool to promote a culture of trust and participation among the different sectors of society and to strengthen the "social contracts" that are the essential foundation for equitable and sustainable development. The use of ICT can influence issues such as the agility and confidence in services provided by public organizations (Avgerou et al., 2005; Avgerou, Smith, Martin & Noorman, 2008).

Irani et al. (2005) show that the results of IS evaluations in the public area must go beyond the traditional models, exploring issues such as: the understanding of the mechanisms of decision making in IT investments within the organization; the understanding of the concept of "value" and its multidimensional aspects; the assessment of the nature (intangible, tangible, financial and non financial) of the benefits of IS/ICT use. This type of evaluation must take into account the complexity of evaluating an incremental system development, technology integration and updates.

In this sense, the framework proposed by Irani et al. (2005) contributes to the evaluation of IS adoption in governmental institutions (Figure 1).

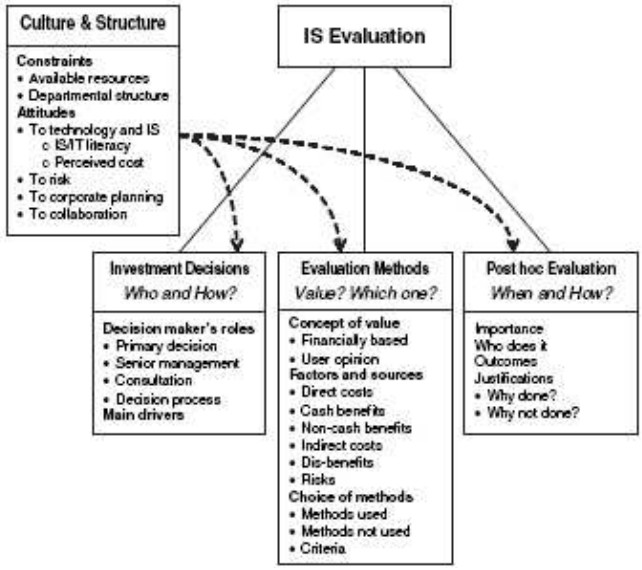

Figure 1: A framework for public sector IS evaluation (Irani et al., 2005:74)

Finally, there should be an assessment of the technology´s post-implementation phase, which should evaluate its relevance and the results achieved, what should be done (but is not), who fails to do it, why it is not done and the lessons learned throughout the implementation process.

Our research adopted this framework (figure 1) for the evaluation of the MWIT adoption results, especially considering the post-implementation stage. The assessment at this stage was also complemented by the taxonomy proposed by Danziger & Andersen (2002) for the evaluation of IT impact in public organizations. This taxonomy involves four areas, namely: *capabilities*, *interactions*, *orientations* and *value distribution*, and their sub dimensions, detailed in Table 1.

Domains	**Specific categories**	
I - *Capabilities*	Information Quality Data access Data quality Efficiency Productivity gains Staff reduction - substitution	Improved (managerial) control Time-saving measures Effectiveness Improved decision making processes Improved products and services Improved planning
II - *Interactions*	Improved coordination-cooperation Citizen-public sector interaction Private – public sectors interaction	Citizen-citizen interaction Organizational control and power
III - *Orientations*	Improved decision making Emphasis on quantitative criteria for decision making Better structuring of problems Increased discretion of decision makers	
IV – *Value distribution*	Protection / improvement of the private sphere Job satisfaction and enrichment Job enlargement	Protection of legal rights Improved standard of health, safety and well being

Table 1: Typology of IT impacts in public organizations (Danziger & Andersen, 2002)

3 - THE IBGE CASE

3.1 Methods

The work adopts a qualitative research approach. As a research strategy we adopted a single case study. According to Yin (2008), this strategy is adequate when the case is rare or represents an extreme situation. The IBGE case is rare due to the massive and intensive use of MWIT by a public organization, supporting a mobile work performed throughout a whole national territory (that displays different physical, economical and cultural features).

According to the objectives established for this study, we collected data via semi-structured interviews and documents analysis, focused on the project and actual use of MWIT in the Census 2007, by the IBGE.

For the interviews we used a semi-structured script based on the main theoretical references considered – Irani et al. (2005) and Danziger & Andersen (2002). Altogether 21 individuals were interviewed at different locations. At the IBGE headquarters in Rio de Janeiro 11 people were interviewed (the IT Director, 03 IT managers, 03 IT technicians and 04 research technicians). At the state unit in Rio de Janeiro 02 people (the IT supervisor and the research coordinator) were interviewed. In other state unit in Rio Grande do Sul (a state in the South of Brazil) 05 people were interviewed (the IT supervisor, 02 research supervisors, and 02 fieldworkers). At the state unit of Pernambuco (a state in the Northeast of Brazil) another 03 people were accessed (the state unit director, a research technician and the IT supervisor). The other source of raw data was a set of internal documents provided by the interviewees, including reports and presentations concerning the project of MWIT adoption and its evaluation. External sources of data were also considered for triangulation, mainly press articles about the case. The data collection occurred from February 2008 to March 2009.

The analysis of the qualitative data collected followed the steps indicated by Miles & Huberman (2005), including the data collection, data reduction, data display and finally the conclusions drawing. We used content analysis procedures with the help of NVivo®. The data were categorized and organized around themes connected and ordered to follow an integrated scheme. The categories were defined after carefully reading and double reading the interviews (which were transcribed and entered into the NVivo®). Furthermore, data from the interviews were triangulated with the documents collected, and with the observations (i.e. of the mobile device adopted and the electronic questionnaires) made during the data collection process.

3.2 The MWIT adoption process

The IBGE is a public organization founded in 1936. Historically it has adopted the most innovative IT to support its work; for instance, the first computer in Brazil was installed in IBGE.

A census operation is a challenging task in a large country like Brazil. In 2007 the IBGE Census held an integrated census operation, which included three different research sets. The first research set was the National Register of Addresses for Statistics Purposes (called CNEFE research), introduced for the first time in the 2007 Census. It aimed at updating the addresses of residential and non-residential units in Brazil, including those in rural areas (where the IBGE captured the geographical coordinates of health, religious and educational institutions, as well as the households). The second research was the Agricultural Census. The third research was a population count (IBGE, 2008). Due to budget restrictions, this count was restricted to municipalities with populations up to 170,000 inhabitants, where the population range impacts on the values provided by the Municipalities Participation Fund (called FPM), managed by the federal government. A set of 21 cities with population above 170,000 was also included, which corresponded to 97% of Brazilian municipalities.

To perform this integrated census operation, the IBGE involved approximately 90,000 people who worked in the process of data collection, supervision, support and administration. In this 2007 census the IBGE introduced the use of a PDA and electronic questionnaires for data collection, abolishing the use of paper based questionnaires, traditionally used in the census so far. The goal was to bring IT to the process of data collection in the field. This was a way to reduce the effort of data input occurring in the IBGE back office. The delay in the data input and tabulation, which was handwritten data, often containing errors, motivated a search for a technological solution that could optimize this process and eliminate rework and checks. The budget provided by the federal government for the 2007 Census also influenced the MWIT adoption. The population count was planned for 2005, five years after the last population census. However, the budget was severely reduced and only allocated by the government in early 2006. Therefore, the IBGE had an unexpectedly short period of 12 months to perform the whole census operation.

The expectation with the use of MWIT was that the data could be collected faster, since it could be sent to IBGE right after its collection in the field. There was also the expectation that resources could be saved, with fewer back office staff working

on data entry and checking within the IBGE. The internal staff structure of IBGE has been reduced over time. The average age of its employees is high, many employees retire and there are difficulties in budgeting for salaries for new workers. With an optimized fieldwork (conducted by temporary workers) the IBGE expected to reduce costs with its internal structure. There were also political pressures faced by the IBGE to update the population count, because it directly influences the funds transferred from the federal government to municipalities. Some of these municipalities were file suits against IBGE, demanding updated information. Therefore, the use of MWIT was considered as a solution to accomplish the task with the available time and funding.

The process of choosing the most appropriate MWIT was complex. Several requirements had to be considered, among them, a choice for a technological infrastructure that could be used in future censuses and surveys. Approximately 16 mobile devices were examined. The mobile device chosen (in a public bidding) was the PDA P550B Mio, provided by a Chinese company (Mitac).

The first pilot test of the mobile solution for the 2007 Census occurred in June 2006. The actual data collection of the census began on the 16th of April 2007 and it was finished in mid-September 2007.Within the areas surveyed, 82,000 of these devices were used. They were equipped with GPS (Global Positioning System). All data collected in the field were transmitted to a central computer in the IBGE headquarters in Rio de Janeiro through 515 IBGE agencies, with 1106 collection points equipped with a PC and an ADSL connection or via satellite, and 4458 collection points equipped with a Bluetooth modem and a telephone line, distributed throughout the country.

More than the PDAs and the infrastructure to transmit data directly from the field, we need to understand the importance and the radical process of innovation represented by the substitution of paper based questionnaires by the electronic ones. The electronic questionnaires allowed a series of innovative operations, among them:

- Automatic check points in each part of the questionnaire - this feature aimed to avoid input errors and missing values during the data collection.
- Automatic skipping – depending on the answers, the question flow path may vary, so that some questions are automatically skipped until the relevant one is reached, which reduces the time and errors during the data collection.
- Automatic sums when required (e.g. total number of cows on a farm).
- Data replication of a questionnaire applied to many people inside a household – some of the data are common to people living inside the same household. The possibility to replicate some of these data reduces significantly the time for data collection.
- Each electronic questionnaire has access to a built-in contextual help and a data dictionary to support the fieldworkers.
- Specific warning alerts to the census workers, informing them about the census processes.
- The GPS allowed the geo-referencing of the surveyed sites and the access to updated information to manage the census processes and progress, such as improving the control of the areas covered by their team.

Similarly to the process of choice and implementation of the new technology, the process of training and adaptation to the MWIT had a short time to occur, due to the deadline pressures of the 2007 Census. Hence, this represented a challenge to the IBGE. The training used Distance Learning and face-to-face meetings complementarily, and it was conducted in "cascade system", whit a small number of experts training other technicians, who in turn trained fieldworkers.

The total exclusion of the use of paper-based questionnaires generated some resistance from the permanent IBGE staff, people who were used to work with paper and had, therefore, a standard for comparison with the new technology features. Common issues raised by staff members included the difficulty of visualizing the questionnaires on the small screen of the PDA, the short battery life of the mobile devices, the delay in moving from one section to another of the electronic questionnaire. However, the temporary census workers were mostly young people who showed an ease and comfort in the use of the new technology and offered no resistance to it, and provided help to the permanent staff.

The technical and procedural adjustments in the mobile solution implemented were made in an incremental way and the tests performed during implementation were not sufficient to cover all the possibilities and variables involved. This was in part due to the infrastructural diversity in a country like Brazil. For example, in many areas within the country, especially those with difficult physical accessibility, it was very hard, if not impossible, to transmit the data via the telephone line. Another issue was the lack of technical support (people, logistics) to cover all the zones of data collection and transmission. The IBGE also faced difficulties in estimating the internal infrastructure for data reception (inside the headquarters).

The IBGE case is rich in demonstrating the complexity of the process of selection and dissemination of MWIT in a public organization, showing elements that must be taken into account in the evaluation of the adoption results, the central issue in the next section.

3.3 Evaluating the results of MWIT adoption

As described in the previous section, the steps involved in a census are complex and include elements such as: people, equipment, telecommunications, infrastructure and logistics. Considering all these elements, the IBGE applied the MWIT expecting to reduce costs and time spent between the start and the finish of the collection and dissemination of data in the census operation.

With the use of a paper based questionnaire the time of data collection (during the interview with the citizen) was much higher, around 40%. The step of the optical reading for data entry was eliminated. The reduction of time could also be extended to the fieldwork supervision, since the supervisors had access to a mobile IS that considers GPS based data, allowing them to oversee all the surveyed areas and the work performed by the fieldworkers with more agility and precision. All the time savings along the process resulted in data processed more quickly, and the census results available earlier for the decision-makers (the government and the society in general).

Reducing the time of data collection and data conference also enabled cost reductions with fieldworkers (who can apply more questionnaires in less time) and back office staff, since it is no longer necessary to mobilize a team to enter and to check the data after their collection.

The cost savings also occurred with the reduction of paper during the Census. In addition to paper costs, there were a whole range of activities such as printing questionnaires, storing them, and logistics – the delivery and return of questionnaires to the IBGE from all the Brazilian states, in short, all these costs were reduced. Despite the amount invested in the MWIT, the costs involved with the use of paper were high. The investment in MWIT can be amortized, because the mobile device can be used in other surveys conducted by IBGE.

The information quality was also identified as a key outcome of the MWIT adoption, since the data passed through automatic check points inside the electronic questionnaire. Therefore, the information that reaches the IBGE central computer is more consistent and accurate, reducing the rework of "cleaning up" and complementing the data.

Besides the quality of data gathered via the electronic questionnaire, the PDA equipped with GPS also allowed geo-referencing of the surveyed units. There were also increases in the quality of information available for the supervision of the fieldwork, which helped to improve the management work, the supervision of productivity and also fraud prevention in the process of data collection.

Another result refers to the upgrade of the IBGE IT infrastructure. Not only the staff from the IT area, but also all the MWIT users went through a process of qualification in order to work with the support of MWIT. The contact with the MWIT was an indirect gain both for the census workers involved and for the public who answered the surveys. For many of them the contact with such type of technology has occurred for the first time, which can be considered as a form of digital inclusion.

Finally, there was a strategic gain with the agility and the organizational effectiveness gains achieved with the use of MWIT, delivering the research results faster. Therefore, several stakeholders benefit from the use of MWIT. The government gets the information faster, which is necessary for making decisions related to public investment and social policies, which directly affect citizens. Similarly, the costs reduction in the census operation also consists in a benefit for the government and the society (which maintains the service through the taxes payment).

In the next section we present a summary, a discussion and some final comments on this article.

4 - DISCUSSION AND FINAL COMMENTS

The IBGE case reveals a set of elements to be considered in the process of MWIT adoption for the provision of services by public organizations. The framework proposed by Irani et al. (2005) helps to analyze these elements, since it considers all the process of technology choice, implementation and diffusion, in order to allow a proper evaluation of the results.

First, we can see that the choice of a new technology in a public organization is influenced by a set of complex elements, including cultural and structural organizational features, political pressures, and the search for effectiveness. The permanent search for technological upgrade of the internal structure and technology in IBGE has influenced the choice for using MWIT,

combined with budgetary restrictions and the search for efficiency. Irani et al. (2005) also highlight a key issue which is the quality of public services. In this sense, the political pressures faced by the IBGE influenced the choice for the MWIT use.

The IBGE culture and structure also influenced the MWIT adoption process. It was a radical process of innovation that was constructed by different areas and actors inside the organization. There were areas of resistance, but also massive collaboration in overcoming all the difficulties and unexpected events that unfold during the technology use in the field, when social and technological elements interact (Markus, 1983). The level of risk in the project was right in all the senses: to change a strong culture (of working based on paper); to train "an army" of almost 90,000 people in a short period of time; to support a new technology application in a wide geographical area. One can realize that the complexity of spreading the IT into the field in a wide geographical area (which is usual when we consider the delivery of public services) brings a set of new challenges to be faced. These findings are corroborated by the United Nations (2010: 5): "*Beyond changes of a technological nature, deeper transformations may be necessary behind the scenes. This is particularly so in contexts where esprit de corps is deeply rooted, where information-sharing is the exception rather than the rule, and where government ICT capacity is limited. In order for a country to excel at e-government, policy makers will usually need to join forces with public administrators to change mindsets and behaviors while offering civil servants the opportunity to acquire the skills needed in the modern organization*."

Concerning the results of adoption, we can also analyze the data with the support of Andersen & Danziger´s (2002) typology already presented in table 1. In table 2 we classify the research results according to this typology. One can notice that the main results of MWIT adoption in the IBGE case are concentrated on the first domain (*capabilities*), involving data and information quality and organizational efficiency and effectiveness improvements (including time savings and costs reductions). The use of MWIT also helped to deliver the information faster.

In the second domain (*interactions*) the MWIT use facilitated the interaction between back office and front office during the census operation and also facilitated the interaction with citizens (e.g. by reducing the time spent to answer to a questionnaire).

In the third domain (*orientations*) the case shows that the MWIT helped to improve the IBGE manager's discretion and decision making on fieldwork operations.

In the fourth domain (*value distribution*) the adoption of MWIT has stimulated the qualification of the IBGE staff. There was also job enrichment, since the census workers incorporated part of back office tasks in their job. An interesting result is this domain is that the diffusion of MWIT among the 82,000 census workers can be seen as a case of digital inclusion in their local communities.

Domains	**Specific categories**	
I - *Capabilities*	*Information Quality* (information for census supervision and census results) *Data access* (data access in the field and from the field with more agility) *Data quality* (automatic check in data collection) *Efficiency* (organizational agility) *Productivity gains* (in the census operation) *Staff reduction* (in back office work)	*Improved managerial control* (of the census operation) *Time-saving measures* (time reduction in field work, in back office work, in service delivery) *Effectiveness* (cost reductions - staff costs, paper costs, storage and logistics costs) *Improved products and services* (agility in delivering public services)
II - Interactions	*Improved coordination* (of census work) *Citizen-public sector interaction* (time reduction in data collection facilitates the interaction with citizens) *Organizational control and power* (over the census work)	
III - *Orientations*	*Improved decision making processes* (on census management and for the information clients – government, citizens, etc.)	
IV – *Value distribution*	*Job satisfaction and enrichment* (Employees get knowledge and skills in the use of a new technology) *Job enlargement* (census workers absorbed part of back office tasks) Dissemination of MWIT in the society	

Table 2: Main results of MWIT adoption in the IBGE case – considering Danziger & Andersen´s (2002) typology

An internal evaluation of the whole 2007 Census was performed by IBGE, and the results are now informing the 2010 Census, which will have even greater dimensions. As a future research issue it will be interesting to understand in which ways the lessons learned from the 2007 Census are going to be absorbed in 2010.

We hope that by presenting a story of IT and organization in combination, as this IBGE case is, helps to clarify future research needs, and that by showcasing its successes and shortcomings we contribute to further moves in the field.

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